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OF
THE ROYAL ASTRONOMICAL SOCIETY
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THE JOURNAL

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VOL. XVI · MARCH, 1922 · No. 3

THEORIES OF THE UNIVERSE

BY J. R. COLLINS

(Retiring President's address, January 24th, 1922)

THE earth itself at one time comprised the universe; the heavens and all beyond, another order of things, in and through which the ordinary laws of nature did not apply. The remnant of this idea still survives to us in certain formalities of speech. We hear of a "universal" language; a "universal" custom, etc., where the reference is clearly to the affairs of the earth alone, but the word "universe" has long since come to be understood in the philosophical sense as the sum of all things, "Of all that we behold from this green earth", all that inhabits space and that may touch our consciousness. The word "university" indicates an institution where not only one but all branches of knowledge may be cultivated.

The views and speculations regarding the universe entertained by the ancients, mainly the Greeks of classic age between 600 and 200 B.C. that have been preserved to us through the intervening centuries, are now so readily available that but little need here be said regarding them.

The concepts of the Babylonians, the Egyptians and other ancient cultured peoples, regarding the universe, are so enshrouded in allegory and metaphor that it seems difficult to determine just what they really were. As regards the Greeks their views were, with variations, pretty much the same in fundamental principles and are strongly marked with evidence of the association of ideas.

Hestia is the central fire or hearth of the universe around which the earth, moon, planets and the spheres of fixed stars revolve: so wrote Pythagoras in the 6th century B.C.

In the same century Anaximander contended that the beginning or "first principle" of the universe was an endless unlimited mass subject to neither old age nor decay and perpetually yielding fresh materials for the series of beings that issue from it. And out of this vague and limitless body sprang a central mass, the results of which we see around us.

About a century later, Anaxagoras explained that all things existed originally in infinitesimal fragments, inextricably combined throughout an infinite universe. The peculiar thing called mind was no less illimitable than the chaotic mass, though finer in texture, alike in all its manifestations, everywhere the same, the first appearance being motion.

All with few exceptions regarded the earth as the centre of the universe. The sun, it was argued by a few, must on account of the eternal fitness of things, be at the centre, as it was but proper that fire as the chief element should command the adoration and homage of all the others as they circled about him,—in the crystal spheres of Eudoxus and Aristotle or the eccentrics and epicycles of Hipparchus and Ptolemy.

When the Copernican theory had definitely pushed the earth from the central position, the idea of the extent of the universe necessarily became enlarged and the term "infinite" appeared less vague. As the great distance of the stars from us became more and more apparent, the idea of an infinite universe seemed to be the most reasonable one.

The recent advances in knowledge regarding the universe through study of the milky way and the problems it suggests, is a worthy tribute to the genius of the human mind. The eagle flying in the face of the sun is as naught to the audacity of man poised on comparatively a speck in space, marshalling the heavenly host about him and calling them by name across an abyss of space that may take years, hundreds of years, thousands and possibly millions of years for light to cross.

Thomas Wright of Durham, England, appears first to have suggested in 1750 that the milky way exhibits to us the form and

outline of the universe viewed from a somewhat central position occupied by the solar system. This was enlarged upon by Kant a few years afterwards, who further suggested that nebulae might be other aggregations of stars comparable in number and dimensions to our galaxy or milky way. Herschel's observations led him to accept this theory regarding the nebulae and he is said to have smilingly remarked that he had discovered 1,500 universes. Later he convinced himself that the theory of "island universes" in many instances at least could not be sustained by closer observation.

Problems connected with the milky way have been developed by Newcomb, Eddington, Turner, Schwarzschild, Kapteyn, Charlier, Shapley, Jeans and others. Whilst leaving much yet to be explained they have added, within the last few years, a world of information regarding our galaxy, and to the modern theory of the universe.

The milky way appears as a great irregular hazy band encircling the heavens, cutting our celestial equator at an angle of 63° in Monoceros, east of Orion (R.A. 7h), and in Aquila near Altair (R.A. 19h), with its highest northern elevation involving Cassiopeia and the northern pole centred in Coma Berenices slightly more than 20 degrees below the handle of the Dipper, R.A. 13h Dec.+27°, and the south pole in Sculptor just south of Cetus R.A. 1h, Dec.−27°. The sun as a member of a loose stellar group appearing to be moving towards a point in Lyra whilst the node of the invariable plane of the solar system exhibits on the plane of the milky way a slow direct motion of 0″.35 per century, which would be equal to a period of about four million centuries, and that the milky way itself exhibits a possible rotation of about 0″.5 per century, or a period of two and a half million centuries.

As star clusters mostly group themselves along the borders of the Milky Way it is thought evident that they are embraced within its confines. The nebulae, especially, mainly locating themselves in the neighbourhood of its poles. The diameter of the milky way has in recent years been variously estimated to be from 30,000 to 300,000 light years, with the solar system some distance from its centre.

In 1904 Kapteyn was enabled to show from available data at

hand that the average direction of motion of all the stars tended to form two intermingling streams. The average direction of motion of one stream being toward a region in Orion about 5° north of the bright star Betelgeuse, R.A. 6h, Declination +13°. The motion of the opposite stream being towards R.A. 18h, Dec. −13°, on the western border of Ophiuchus. Both of these points being involved in regions of the Milky Way at opposite diameters and parallel to its plane approximately. This "preferential motion" as it has been termed, has been confirmed by Eddington, Dyson, and others. Turner has suggested that this apparent intermingling of streams in opposite directions might possibly be due to the in and out motions of the stars in greatly elongated orbits about a common centre of all, as viewed from our position within the galaxy.

While Eddington finds support for such a supposition, Jeans contends that such motions could only exist in a spherical universe, which ours does not appear to be. The great difficulty in the way of Turner's suggestion, remarks Eddington, is that "it seems inevitable that there should be a great congestion of stars in the neighbourhood of the centre. It is possible to argue that one of the dense patches of stars either in the Cygnus or Sagittarius regions of the Milky Way is the actually congested centre of the stellar system".

Some few years ago Keeler at the Lick Observatory was able with the great Crossley reflector, to photograph a great number of nebulae that had hitherto been too faint to secure with the means at that time available. Many of these were of the spiral type which have apparently a velocity about twenty times greater than the average star and a rotational velocity of the same order. These have suggested again the "island universe", theory, that they may be galaxies away out in space beyond our own. Some of our authorities contend that they are, mainly because the dimensions of the Milky Way are too limited to contain them, whilst others, notably Shapley contend that the methods of star gauging would allow ample expansion of the Milky Way to contain all celestial objects at present known to exist.

A remarkably clear presentation of these two contending views of our universe appears in the Bulletin of the National Research

Council of The National Academy of Sciences, Washington, for May 1921.

Harlow Shapley, formerly of the Mount Wilson Observatory and now director of the Harvard Observatory, presents the case for the unit universe theory, and H. D. Curtis, Director of the Allegheny Observatory, presents that of the island universe theory.

Astronomers, says Shapley, "agree on the distances of the nearby stars and stellar groups—the scale of the part of the universe that we may call the solar domain. But as yet there is lack of agreement relative to the distances of remote clusters, stars and star clouds—the scale of the total galactic system. The disagreement in this last particular is not a small difference of a few per cent., an argument on minor detail; it is a matter of a thousand per cent. or more", as regards star gauging, all agree that as star clusters show a systematized distribution along the zone of the milky way, they must be associated with it and their distances can properly be used to determine its dimensions. Therefore, further says Shapley, "The existence of 15th magnitude B-type stars in the Hercules cluster seems to answer decisively the question of its distance, because B stars in the solar neighbourhood are invariably giants (more than a hundred times as bright as the sun), and such a giant star appear to be of the fifteenth magnitude only if it is more than 30,000 light-years away.

When we accept the view that the distance of the Hercules cluster is such that its stellar phenomena—its brightest stars, typical giants, its Cepheids comparable with our own—then it follows that fainter, smaller, globular clusters are still more distant than 30,000 light-years. One-third of those now known are more distant than 100,000 light-years, the most distant is more distant than 200,000 light-years away. It appears that we are not far from the centre of a local cluster or cloud, but that cloud is at least 50,000 light years from the galactic centre".

Curtis questions the accuracy of Shapley's method of determining the magnitudes involved and is disinclined to accept his conclusions, but adopts apparently a similar method, gauging the distance by a comparison of the angular dimensions of these minute spirals with the great spiral nebula in Andromeda and

assuming them to be of the same proportions, deduces their distance accordingly. He says "If the nebula of Andromeda is but 20,000 light years distant, the minute spirals would need to be at distances of the order of 10,000,000 light-years, or far outside the greater dimensions postulated for the galaxy". Other lines of argument are employed in the discussion, which we cannot here refer to, but it must appear that the use of the term "universe" in this limited way is unfortunate as it but introduces confusion into the average mind. Whether these objects be directly involved in our own galaxy or are other galaxies further out in space may be a debatable question but that they are part of a unit universe is self evident from the fact that the light from them causes a chemical change on the photographic plate in leaving their image there, and a physical effect on the retina of the observer's eye; thus proving that a direct influence bridges the gulf from them to us no matter how great the distance may be.

Whilst other views may be entertained, the general trend of modern astronomical theory based on observation and experience, is to regard provisionally the universe as finite both in time and in space. Newcomb puts the case in a few words thus: "Though to superficial observation it might seem that the great bodies of the universe could radiate their light and heat forever, the modern generalizations of physics show that such cannot be the case and science has nothing, even to suggest the possibility of its restoration". And again ,"The universe, so far as we can see it, is a bounded whole. It is surrounded by an immense girdle of stars, which, to our vision, appears as the Milky Way. While we cannot set exact limits to its distance, we may yet confidently say that it is bounded.

We cannot set any definite limit and say beyond this nothing exists. What we can say is that the region containing the visible stars has some approximation to a boundary". In discussing stellar motions within our galaxy Eddington observes, "The apparent analogy with the kinetic theory of gases is rejected altogether, and it is taken as a fundamental principle that the stars describe paths under the general attraction of the stellar system without interfering with one another. We are justified in thinking of the stellar orbits as paths that have actually been

traversed, and not as mere theoretical curves. We have no means of estimating the age of the stellar system, but perhaps there is no harm in having some such figure as 10^{10} years (ten thousand million) at the back of our minds in thinking of these questions".

Arrhenius, however, finding no place in the mechanical universe for perpetual motion, takes refuge in the nebulae as orders or systems where ordinary mechanical principles are reversed and so they gather up the waste of dissipated energy and thus perpetually rejuvenate the otherwise finite universe.

Sometimes we hear it said that the great numbers employed in astronomical discussion are utterly meaningless to the average mind, but a little reflection will show that this need not be the case; as Lord Kelvin once remarked, "It is as easy to comprehend a million as to comprehend a hundred, for, to fully comprehend a hundred, it is necessary to count the number, but we cannot do this in a fraction of a second, but in that time the three figures representing the hundred flash through the mind with a definite meaning in the same way that the three groups of figures representing millions do".

It has been urged that if the universe has a limit many of the stars with high velocity might wander away and be lost, in fact that the whole universe might thus be entirely dissipated. This however need not be, cannot be, if we accept the theory of an ether having boundaries.

The physicists generally have of late years attributed the properties of matter as due to the ether in which they are enshrouded rather than to matter itself, and further that matter may be but specialized conditions of the ether itself. If we assign a limit to the ether it is then obvious that it would be impossible for matter to pierce the surface and escape into outer nothingness. Of course just now the theory of the ether is being questioned in some quarters, but any substitute must cover its supposed capabilities and need not affect our general conclusions.

The view that the theory of "relativity" presents, regarding limits of the universe, as presented by Moritz Schlick and approved by Einstein is briefly stated thus: "A sphere is bounded by its surface, the latter cutting it out of space as a part of it; spherical space however, is not a part of infinite space, but has simply no

limits. If I start out from a point of our spherical world and continually proceed along a 'straight line', I shall never reach a limiting surface; the 'crystal dome', which according to the ancients was supposed to encompass the universe, exists just as little for Einstein as it did for Bruno. There is no space outside the world; space exists only in so far as matter exists, for space in itself is merely a product of abstraction.

The world is not confined by any boundaries, and is yet harmoniously complete in itself. It is saved from the danger of becoming desolate for no energy or matter can wander off to infinity, because space is *not* infinite. The infinite space of the cosmos has certainly had to be rejected; but this does not signify such sacrifice as to reduce the sublimity of the picture of the world".

The application of mechanical principles in the interpretation of the universe has but deepened the mystery concerning its origin and ultimate destiny. There seems to be no escape from the conclusion that a perpetual motion "world machine" on strictly mechanical principles, is as impossible as for any other machine for precisely similar reasons.

Physisists have been able to show us recently by direct experiment that there are very good reasons for believing that "mass", which is essentially involved in any modern definition of "matter" is but a function of velocity.

When the velocity is great, an increase of the quantity known as "mass" manifests itself with the increase of velocity in a proportion which, if maintained, should show infinite "mass" when the velocity exceeds that of light.

The varied forms that have flourished on the earth from the remote past to the present have left their decipherable records within its depths or upon its surface. The general properties of bodies; the molecular, atomic and interatomic structures as well as that of the ether, have all been potential objects of knowledge for ages, though it is but in comparatively recent years that they have become contributors to the various branches of systematized knowledge that are now growing up about us.

The light from the stars has impinged on the retina from the time man first appeared upon the earth, though it is but recently he has by optical aid been able to multiply them a million fold.

Nature's agencies are ever willing further to render up their secrets to application, proper methods of approach, and means of investigation, in the distant star and all else that touches our consciousness.

"If we listen to the quiet voices
They will speak if we will hear;
They will tell us that the
Finite to the infinite is near."

ANNUAL GENERAL MEETING

THE Annual General Meeting of the Society was held in the Physics Building of the University of Toronto, at 8 p.m., January 17, 1922, the President, Mr. J. R. Collins, in the chair.

On motion, the minutes of the last annual meeting, printed in the JOURNAL, were approved.

Miss E. M. Budd and Dr. J. B. Fraser were appointed scrutineers to count the ballots cast for the election of the officers for 1922.

The Gereral Secretary, presented and read his report for 1921; and on his motion, seconded by Prof. C. A. Chant, it was received and adopted.

The Recorder presented and read the report of the General Treasurer for 1921; and on motion by A. F. Miller, seconded by A. F. Hunter, it was received and adopted. In discussing the report, Dr. C. A. Chant, the Editor and Librarian, stated that as the Society's expenditures during 1920 were $500 greater than its receipts it was necessary to retrench seriously during 1921. By reducing the size of the JOURNAL and combining two numbers into one, also by having no binding done and making only absolutely necessary purchases for the Library, the expenditures have been brought within the receipts. He showed the urgent need of greater funds to carry on the work satisfactorily.

The Librarian presented and read his report for 1921; and on his motion, seconded by A. F. Hunter, it was received and adopted.

The General Secretary presented and read the reports from the Secretaries and Treasurers of the Montreal and Ottawa Centres; and on his motion, seconded by W. E. W. Jackson, they were received and adopted.

The scrutineers reported that the following officers had been elected for 1922.

HONORARY PRESIDENT: Hon. R. H. GRANT, Minister of Education for Ontario, Toronto.

PRESIDENT: W. E. W. JACKSON, M.A., Toronto.

FIRST VICE-PRESIDENT: WM. BRUCE, J.P., Hamilton.
SECOND VICE-PRESIDENT: JOHN SATTERLY, M.A., D.Sc., Toronto.
GENERAL SECRETARY: A. F. HUNTER, M.A., Toronto.
GENERAL TREASURER: H. W. BARKER, Toronto.
RECORDER: JOSEPH A. PEARCE, B.A.
LIBRARIAN: PROF. C. A. CHANT.
CURATOR: ROBERT S. DUNCAN.
COUNCIL: MGR. C. P. CHOQUETTE, M.A., Lic. Scs., Montreal; L. GILCHRIST, M.A., Ph.D., Toronto; R. A. GRAY, B.A., Toronto; A. R. HASSARD, B.C.L., Toronto; J. H. HORNING, B.A., Toronto; H. R. KINSGTON, M.A., Ph.D., London, Ont.; OTTO KLOTZ, LL.D., D.Sc., F.R.A.S., Ottawa; SIR JOSEPH POPE, K.C.M.G., Ottawa; STUART STRATHY, Toronto; DR. W. M. WUNDER, Toronto.

Prof. J. Satterly asked that he be relieved from acting in the position to which he had been elected.

The President declared that the above officers, with the exception of the Second Vice-President, were elected for the year 1922. The President-elect then took the chair, and thanked the Society for the honour bestowed upon him.

It was moved by Prof. C. A. Chant, seconded by J. R. Collins, that the auditors, Dr. J. B. Fraser and A. R. Hassard, be thanked for their past services, and that they be asked to continue in their office for 1922.—Carried.

The meeting was then adjourned.

J. A. PEARCE, *Recorder.*

REPORT OF THE GENERAL SECRETARY FOR 1921

A substantial increase in the membership of the Society has taken place during the year 1921, the total being now 507 as against 441 at the close of the preceeding year. The following table contains the figures according to Centres, as shown by the Society's mailing list at January 1st, 1922:—

Centre	1920	1921
Toronto	176	205
Guelph	18	17

Ottawa	92	88
Hamilton	10	9
Victoria, B.C.	50	60
Regina	4	..
Peterborough	4	..
Winnipeg	48	54
Montreal	39	74
	441	507

In addition to these ordinary members there are 18 honorary fellows, 2 corresponding members and 23 subscribers to the JOURNAL who do not hold full membership, making a total membership of 550.

There have been 18 meetings held at Toronto during the Society's year just closed, at which 19 addresses and lectures were delivered as follows:—

1921

Jan. 25—J. R. Collins, "New Stars".
Feb. 1—Prof. C. A. Chant, "The Planets and their Ways".
Feb. 8—Prof. C. A. Chant, "The Moon and its Service to us".
Feb. 15—Prof. C. A. Chant, "News about the Stars".
Mar. 1—Sir Frederic Stupart, "Facts, Fallacies and Fancies about the Climate".
Mar. 15—Prof. Alfred Baker, "Sun Dials".
Mar. 29—J. A. Pearce, B.A., "Magnetic Observations in the Field".
April 12—N. J. Ogilvie, D.L.S., "The Geodetic Survey of Canada".
April 26—Samuel Beatty, M.A., Ph.D., "The Notion of Infinity in Mathematics".
May 10—J. S. Plaskett, D.Sc., "Work of the Dominion Astrophysical Observatory, Victoria, B.C."
May 25—J. B. Fraser, M.D., "The Influence of Astronomy on Medicine".
A. R. Hassard, B.C.L., "The Influence of Astronomy on Agriculture".
A. F. Miller, "Design for a Simple Apparatus for projecting the sun's image".
May 28—Prof. C. A. Chant, "Winnecke's Comet; and How the Size of the Star Betelgeuse was measured".
June 6—Open Air Meeting.
Oct. 18—A. F. Hunter, M.A., "Rainbows, Fogbows and their Associated Phenomena".
Nov. 1—A. F. Miller, "The Influence of Astronomy on the Science of Chemistry".

Nov. 15—Dr. A. D. Watson, "Astronomy in a Poet's Life".
Nov. 29—John A. Paterson, K.C., M.A., "Percival Lowell; his Life and Works".
Dec. 13—John Patterson, M.A., F.R.S.C., "Aerial Navigation".

In aid of the work of the Royal Astronomical Society of Canada through its public meetings and lectures, the Royal Canadian Institute provided, amongst others, lectures on subjects within the scope of this Society as follows:—
April 23, Prof. A. S. Eve, "The Rotation of the Earth."
April 30, Dr. Heber D. Curtis, "The Size of our Universe."
January 14, 1922, Prof. W. J. Humphreys, "Fogs, Clouds and Thunderstorms."

At the meeting of the American Association for the Advancement of Science held in Toronto, December 27-30, 1921, this Society held a joint meeting with Section D (Astronomy) of the visiting society. At the sessions of the joint meeting the program contained 24 papers, all on astronomical subjects. The closing year has, accordingly, been prolific in new work on astronomy and its allied sciences.

Respectfully submitted,
A. F. HUNTER, *General Secretary.*

REPORT OF THE OTTAWA CENTRE

During the past year there have been eight regular meetings of the Society. There were six lectures in the Spring Term, all of which were held in the Carnegie Library. The attendance at these lectures was fair, averaging about 20 or 25. Owing to the increased demand for lecture rooms we were unable to secure room at Carnegie Library for the Fall lectures, Mr. Ogilvie, Supt. of Geodetic Survey, very kindly placed their lecture room at our disposal. Two lectures were held in this hall; the attendance was not so good as down town, owing to the difficulty in coming so far.

There have been nine members elected during the last year, three resignations and four removals.

The following lectures were given during the year:—

(SPRING TERM)

Dr. R. E. DeLury, "Recent Developments in Astronomy"
C. C. Smith, B.A., "The Size of the Stars"

Dr. F. C. Henroteau, "The Size of the Universe"
Dr. Lachlan Gilchrist, "Atoms and their Messages from Stars"
R. A. A. Johnston, F.R.S.C., "Meteorites"
G. H. Herriot, B.A.Sc., D.L.S., "Refraction"
(FALL TERM)
J. P. Henderson, M.A., "Wireless down the Mackenzie"
A. H. Miller, M.A. (Oxon.), "Gravity in the Far North"

The following are the officers for 1922:—

PRESIDENT: R. E. DeLURY, Ph.D.
VICE-PRESIDENT: G. H. HERRIOT, B.A.Sc.;
SECRETARY: R. J. McDIARMID, Ph.D.;
TREASURER: D. B. NUGENT, M.A.;
COUNCIL: T. H. Tanton, Ph.D.; A. M. Narroway, D.L.S.; C. A. French, B.A.; and Past Presidents: Otto Klotz, LL.D., D.Sc., F.R.A.S.; C. A. Bigger, D.L.S.; F. A. McDiarmid, M.A.; R. M. Stewart, M.A.; and J. J. McArthur, D.L.S.

R. J. McDIARMID, *Secretary.*

REPORT OF THE MONTREAL CENTRE

The Annual Meeting of the Montreal Centre was held in the Physics Building of the McGill University on Thursday, December 15th, 1921. In the absence of the President, who unfortunately was indisposed, the chair was occupied by Mr. Justice Howard, the Vice-President. The attendance was about 60.

The Vice-President called upon the Secretary-Treasurer for his financial report for 1921. Rev. W. T. B. Crombie, presented his report, which appears under the General Treasurer's Report on page 89.

Mr. Crombie, reported that the membership which stood at 44 at the end of 1920, is now 68; 30 members having been added and 6 removed.

The following officers for 1922 were then elected:

PRESIDENT: H. E. S. ASBURY;
1ST VICE-PRES.: E. E. HOWARD, K.C.;
2ND VICE-PRES.: A. S. EVE, M.A., C.B.E., D.Sc., F.R.S.;
SEC.-TREAS.: Rev. W. T. B. CROMBIE, M.A., B.D.;
RECORDER: H. E. MARKHAM;

COUNCIL: Mgr. C. P. Choquette, M.A., Lic. Scs.; Miss M. Ellicott; John Corway; Prof. L. V. King, M.A., D.Sc., F.R.S.C.; F. R. Robert; Geo. Sample; James Weir, B.Sc.

H. E. MARKHAM, *Recorder.*

REPORT OF THE WINNIPEG CENTRE

The plan of having a short talk, of about ten minutes, in addition to the lecture of the evening, has been followed throughout the year, and has proved very successful. Among the subjects included in these short talks are—The Star Algol; The Planet Saturn; Constellation Orion; Constellations of the Northern Sky; The Milky Way; The Zodiac.

Observation evenings were planned for February 23rd, October 12th, 13th, 26th, 27th. On account of weather conditions, observation was possible only on two of these evenings, October 12th and 13th. These proved very successful, and the plan followed in these meetings, of having only one-fourth of the membership on a single evening, proved quite satisfactory. In place of the observation which was planned for February 23rd, Mr. Bastin gave a talk on Jupiter, Saturn and other objects which would have been seen had the sky been clear.

The following lectures have been given during the year:

Jan. 12—Dr. E. M. Burwash, "The Planetesimal Theory of the Earth's Origin".
Jan. 26—Mr. H. B. Allan, "Are Other Worlds Inhabited?"
Feb. 9—Prof. Frank Allen, "The Einstein Theory of Relativity".
Mar. 9—Dr. C. D. Miller, "Light as a Wave Motion".
Mar. 23—Prof. W. T. Allison, "Early Conceptions of the Universe".
April 13—Prof. N. R. Wilson, "Comets".
Nov. 9—Mr. H. B. Allan, "The Moon".
Nov. 30—Prof. L. A. H. Warren, "Double Stars".

The membership of the Society has increased somewhat, there being 54 members for the year 1921.

The following officers were elected for the year 1922:

PRESIDENT: H. B. ALLAN.
VICE-PRESIDENT: MRS. E. L. TAYLOR.
SEC.-TREASURER: PROF. C. D. MILLER.
EXECUTIVE COUNCIL: Prof. L. A. H. Warren, C. E. Bastin, J. H. Kolb, G. K. Johnston, A. W. Meggett.

C. D. MILLER, *Sec.-Treasurer.*

LIBRARIAN'S REPORT FOR 1921

The number of publications received during the year 1921 was as follows:

From the British Empire, 42 titles	246 received
From the United States, 55 titles	168 received
From other countries, 30 titles	103 received
Total of	517 received

On account of shortage of funds no binding was done, nor were any books purchased during the year. A number of copies of the reprint "The Festival of the Dead" are still on hand.

C. A. CHANT, *Librarian.*

FINANCIAL STATEMENT FOR YEAR ENDING DECEMBER 31ST, 1921

RECEIPTS

Cash in Bank December 31st	$246.45
Grant from Dominion Government	2,000.00
Grant from Ontario Government	600.00
Grant from City of Toronto	100.00
University of Toronto (50 copies Journal)	100.00
Fees from Members	883.50
Interest and discount	132.11
Sundry receipts (sale of magazines, etc.)	112.22
	$4,174.28

DISBURSEMENTS

Publication "Journal" and "Handbook"	$2,096.58
Library account (books, etc.)	137.71
Stationery, stamps and exchange	263.00
Salaries (Ass't Librarian and Caretaker)	430.00
Rent of rooms	120.00
Grant to Ottawa Centre	100.00
Grant to Victoria Centre	50.00
Grant to Montreal Centre	60.00
Grant to Winnipeg Centre	75.00
Fire insurance (to 1924)	38.72
Miscellaneous expenditure	6.21
Local Expenses in Toronto:	

Printing for Public Meetings, etc	71.98
Rent for rooms for Meetings	51.50
"At-Home" expenses	75.00
	$3,575.70
Balance in Bank	598.58
	$4,174.28

Audited and found correct,
(Signed) A. R. HASSARD.
(Signed) J. B. FRASER, M.D.

Respectfully submitted,
(Signed) H. W. BARKER,
General Treasurer.

OTTAWA CENTRE, FINANCIAL STATEMENT, 1921

RECEIPTS

Balance on hand	$7.86
Grant from General Society	100.00
	$107.86

EXPENDITURES

Lectures	$44.00
Printing	38.62
Postage, Exchange, Drafts, etc	7.30
Advertising	4.00
	$93.92
Balance on hand	13.94
	$107.86

Examined and found correct,
(Signed) D. ROBERTSON.
December 16th, 1921.

Respectfully submitted,
D. B. NUGENT, *Treasurer.*

MONTREAL CENTRE, FINANCIAL STATEMENT, DECEMBER 16, 1920-DECEMBER 13, 1921

RECEIPTS

Balance Cash on hand, December 15th, 1920	$85.06
Fees from 66 members for 1921	132.00
Fees from 2 members for 1922	4.00
Grant from General Treasurer	60.00
Interest on Bank Deposit	1.75
Total Receipts	$282.81

EXPENDITURES

Fees sent General Treasurer	$128.00
Advertisement of meetings	37.24
Postage (including 600 notice cards)	11.20
Printing of notice cards (600)	4.57
Expenses of Dr. Plaskett (Lecturer)	15.40
Expenses of Local Secretary (as ordered by Council)	18.15
Expenses of Lantern Operator	10.00
Expenses of Janitor	10.00
Total Expenditures	$234.56
December 13th, 1921. Balance on hand	$48.25

Respectfully submitted,
W. T. B. CROMBIE, *Secretary-Treasurer.*

Adopted at the Annual Meeting of
the Society, December 15th, 1921.

WINNIPEG CENTRE, TREASURER'S REPORT, 1921

RECEIPTS

Balance on hand, January 1921	$82.01
Fees from 49 subscriptions 1921	98,00
Fees from 4 subscriptions 1922	8.00
Grant from Toronto	75.00
Interest on bank deposit	.93
Total	$263.94

EXPENDITURES

Remittance of fees to Toronto	$108.00
Expenses	75.96
Total	$183.96
Balance on hand December 14th, 1921	$79.98

Respectfully submitted,

C. D. MILLER, *Sec.-Treasurer.*

Audited and found correct,
(Signed) C. E. BASTIN,
H. B. ALLAN, *Auditors.*

TEMPERATURE REGULATION OF SPECTROGRAPH AND MIRROR

By J. S. Plaskett

EFFECTIVE temperature regulation of the stellar spectrograph has been recognized almost from the first as essential if accurate wave-lengths or radial velocities are to be obtained. Although the spectrograph used by Vogel at Potsdam in the photographic determination of stellar radial velocities, the first successful attempt to measure the small displacements involved, had no provision for maintaining constant temperature, nor had the universal spectroscopes of Brashear, which were so generally used in the beginnings of stellar spectroscopy in America, any means of temperature control, the necessity of such regulation if accurate results were to be secured, was soon recognized. Thus we see that Campbell, who may justly be considered as the founder of accurate radial velocity determinations, wrapped the first Mills spectrograph in an insulating cover of woollen blankets, even though the change in temperature at Mr. Hamilton during observing hours was generally very small. This was soon superseded by an outer wooden case supplied with heating wires on the inside, the current in which was turned on and off automatically by a thermostat. This method was improved by Hartmann, who used sensitive mercury contact thermometers to control the heat, and all recent stellar spectrographs have been provided with an automatic method of maintaining constant temperature.

In designing the spectrograph for the 72-inch telescope it was from the first proposed to provide it with a more certain and accurate means of temperature regulation than can be given by even a sensitive mercury contact thermometer. The Ottawa spectrographs, designed by myself, were provided with this system of control, the heating wires being placed on the inside of the outer temperature case and the controlling thermometer or thermometers on the outside of the spectrograph proper adjacent to the prisms. Although this method undoubtedly maintained the temperature

of the case constant, within perhaps a fifth of a degree centigrade, it was found that the temperature inside the spectrograph did not remain constant but followed, on a much reduced scale and with some considerable lag, the change of outside temperature. As under observing conditions at Ottawa this was practically always falling, and frequently over a considerable range, the result was that the temperature of the prism box frequently fell about half a degree during a few hours observing. This fall of temperature inside, while that of the outer case presumably remained stationary, was ascribed to metallic conduction through the exposed attaching frame and slit head. While such a slow change as this is not likely ordinarily to introduce much error, it was felt very desirable that it should be overcome and the temperature of the spectrograph proper maintained constant for some time before and during the whole time observations were being made. It was evidently not sufficient to control the temperature of the outer case and some additional means must be provided to maintain the temperature constant inside the spectrograph proper as well as in the case. While it would be possible to place an additional thermostat inside, controlling part of the heating circuit, it would be difficult to set these thermostats to work together properly at the same temperature, especially as the surface of the capillary in which the controlling platimum wire dips is continually becoming oxidized and the column frequently becomes broken, introducing irregularities and uncertainties into the control. On the other hand if a single controlling thermometer or thermostat were placed inside the spectrograph near the prisms, there would likely then be so much lag between the heating and cooling of the outer case and the response of the thermostat as to make undesirably great oscillations of temperature in the outside case. These oscillations would be liable to produce local expansion or contraction of the metal parts which might easily introduce relative displacement of star and spark spectra and thus give erroneous results.

The success of the Callendar Recorder as applied by R. M. Stewart at the Dominion Observatory, Ottawa, to record and regulate the temperature of the Riefler standard clock, and the similar success of a special adaptation of the same instrument to the regulation of the temperature of the Cape spectrograph, decided me

to use a similar method for controlling and recording the temperature of the new spectrograph. While it would have been possible to use the same method as that at the Cape, this seemed unnecessarily complicated and it was felt that entirely satisfactory results could be secured by using the regular type of recorder with an automatic electric contact for making and breaking the heating circuit.

Consequently as soon as the design of the spectrograph was completed and the instrument was ordered from the Warner & Swasey Co., an order was sent through the Topley Co., of Ottawa, to the Cambridge Scientific Instrument Co., for a Callendar Recorder of the laboratory pattern, provided with an adjustable electric contact for regulating as well as recording the temperature. This order was given in the spring of 1916 but, owing to war work and ante-war difficulties, was not completed until December, 1920, reaching Victoria about February 1, 1921. I am much indebted to Mr. G. S. Whipple, the manager of the Cambridge Scientific Instrument Co., for his interest and care in the production of the equipment. It was at first proposed to use one recorder, not only for regulating and recording the spectrograph temperature, but also for recording dome and mirror temperatures. However, owing to the greater sensitiveness required for the spectrograph recorder and its use as regulator of temperature, the advice of Mr. Whipple was followed and a separate recorder was obtained for dome and mirror temperatures.

The installation of the equipment was rather troublesome as in order to avoid having wires trailing over the floor, it was necessary to carry the leads, two four-wire braided cables, down the polar axis and through the declination axis to the tube. Through the skill and experience of T. T. Hutchinson, who has charge of the mechanical and electrical equipment of the telescope and assists in the night observations, this was accomplished in a very workmanlike and satisfactory manner. The two recorders are mounted side by side between the sidereal and mean time clocks on the south side of the north pier as shown in Plate I, the right hand one regulating and recording the temperature of the spectrograph and the left hand recording the temperature of dome and mirror.

In order to understand the method of operation and realize

the advantages of the instrument for the required purpose, it is probably desirable to briefly describe the principle on which it operates, and its application to the temperature control of the spectrograph.

The thermometer element, consisting of a coil of platinum wire, forms one arm of a Wheatstone bridge. The recording pen carries the slider which makes contact on the bridge wire and is moved back and forward by means of an ingenious motor device driven by clockwork. This motor is controlled by electric contacts on the boom attached to the rotating coil of the bridge galvanometer, which is of the D'Arsonval type and is shown at the upper left of the recorders in Plate I. If the temperature around the thermometer coil increases, the resistance of this coil increases, which throws the bridge out of balance, causing the boom of the galvanometer to make contact on one side. This starts the motor device operating, which draws the pen to the right, recording increased temperature on a clock driven drum. If, on the contrary, the temperature falls, the galvanometer moves in the opposite direction making contact on the opposite side and drawing the pen to the left. As soon as the pen, and consequently the bridge wire slider, has been drawn far enough to restore the balance, the galvanometer swings free of the contact and the pen remains stationary until there is further change in the temperature, thus making a continuous record. An adjustable electric contact, which is shown just below the drum on the right hand recorder and which can be set to any desired position along the temperature scale, can be attached when desired and is tripped by the pen when it reaches the required temperature division thus throwing off, through an intermediate relay, the heating current. The Callendar Recorder thus serves not only to record but to control the temperature of any instrument or space and possesses three distinct advantages over any other device for this purpose. First—It can be made as sensitive as desired by suitably arranging the ratios in the bridge arms. For example in the spectrograph recorder a change of temperature of one degree Centigrade moves the recording pen over a distance of about 20 mm on the sheet. It is evident, therefore, that the temperatures can be read to hundredths of degrees. While the control contact does not respond

until there is a movement of about two hundredths of a degree and while the effect continues for about five hundredths of a degree longer, it is still much more sensitive than any previous thermostatic device used in stellar spectrographs. Second—As the thermometer element consists of a certain length of fine platinum wire it is evident that it can be easily divided and distributed in any way desired over the instrument or space to be controlled, is not confined to any one situation and will register and control the average temperature of the space in which it is distributed. Third—Owing to the fineness of the platimum wire it will respond much more quickly to a change of temperature than any mercury contact thermometer or other thermostatic device.

It is evident, therefore, that the use of the Callendar Recorder in the spectrograph will give a much more sensitive and accurate temperature regulation than is possible by the old methods, and will at the same time give a continuous accurate record of the temperature of the space in which the wire resistance thermometer is located. Such a record will be valuable in showing at a glance the temperature of the spectrograph at any time during any observation and will also be of obvious use in determining when and to what temperature to set the automatic controlling device.

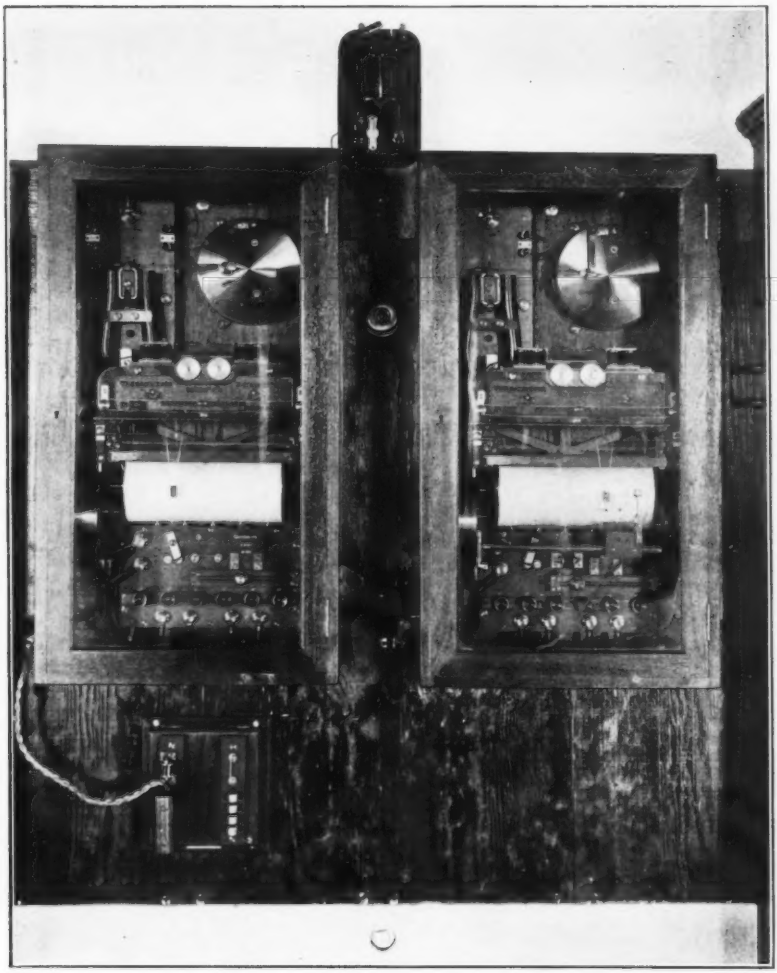
The possibility of distributing the thermometer and controlling element in any desired manner over the space to be controlled, obviously lends itself to overcoming the difficulty mentioned above of the gradual fall of temperature inside the spectrograph as the difference between inside and outside temperatures increases. As part of the resistance thermometer is placed near the heating coils and part inside the spectrograph box, the temperature over the whole instrument will evidently be kept much more uniform than when the thermostatic device is in one position only in the outside case. Further, owing to convection currents and to stratification inside the case and spectrograph, there is a strong probability with a moving spectrograph, that a control element situated in one position on the inside case may produce markedly different temperatures of the optical parts when telescope and spectroscope occupy greatly different angular positions.

The wire of the resistance thermometer for the spectrograph

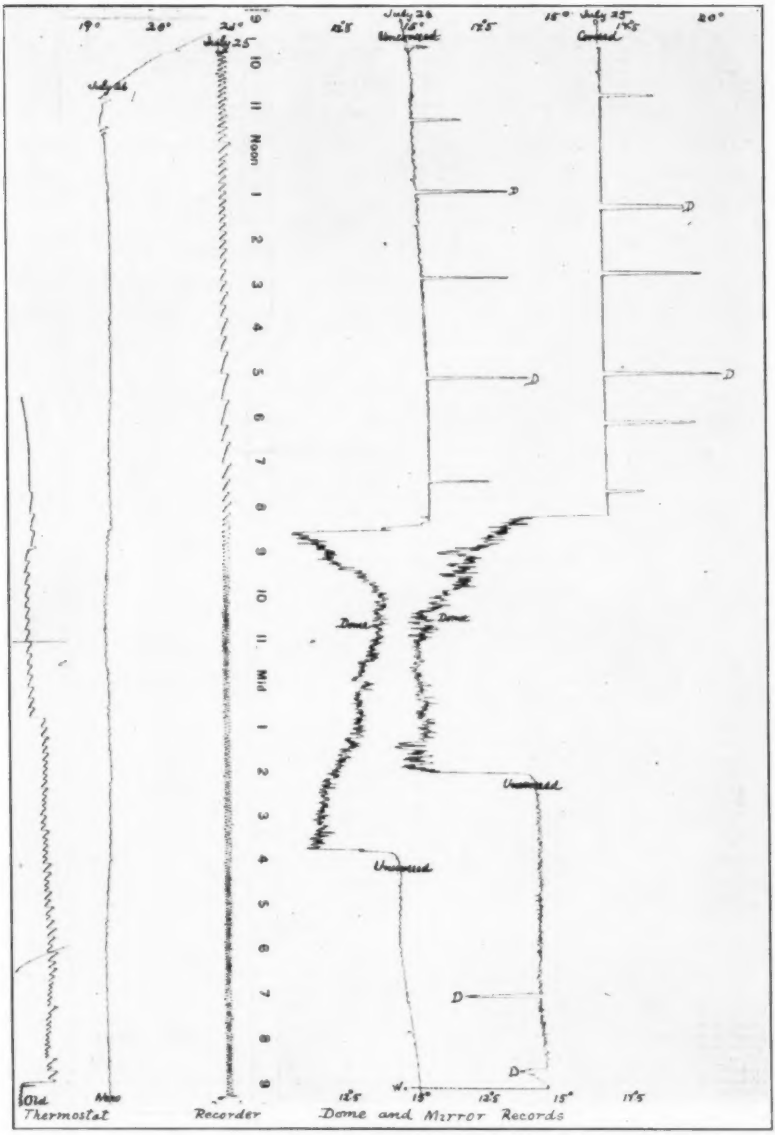
was thence divided into five approximately equal parts each being, wound on a separate insulating frame. Two of these frames, which are all connected in series, are attached to the outside of the spectrograph box on opposite sides and situated about three-fourths of an inch away from the heating wires which are distributed as uniformly as possible over the inside of the felt lined temperature case. The other three sections are placed inside the spectrograph box as equably situated as possible with respect to the prisms and objectives. Two-fifths of the control element then is near the heating source and must form the principal factor in the comparatively rapid turning on and off of the heat. The other three-fifths, owing to its situation inside the spectrograph box, can not partake in or be affected by the rapid, but of course relatively small, oscillations of temperature in the outer case. It must, nevertheless, have sixty per cent. of the controlling effect and evidently influences the frequency with which the heat is turned on and off by the movement of the recording pen which necessarily registers the total change of resistance in all five elements in series. It is evident that if for example there is the tendency before mentioned of a fall of temperature around the prisms, the lower resistance thereby introduced in three-fifths of the control element must be compensated by a relatively higher resistance corresponding to greater temperature of the two-fifths resistance in the outer case. The temperature in the outer case will thus be automatically increased until approximate equalization of temperatures between case and prism box again occurs. Further if, as is likely, stratification or convection effects occur in case or spectrograph, it is evident that by the division into five equal parts and the symmetrical distribution of the controlling element over the interior of case and spectrograph any local changes of temperature due to such stratification or to change of stratification caused by change of position of the spectrograph, will be minimized and rapidly compensated and equalized. Obviously no single thermostatic device can approach the constancy and uniformity obtained by the symmetrical distribution of the control elements over the interior of both case and spectrograph.

A comparison of the two methods is shown in Plate II, the two records at the left of the figure showing the temperature ranges

PLATE I



THE CALLENDAR RECORDERS



TYPICAL SPECTROGRAPH, DOME AND MIRROR RECORDS

given by the mercury contact thermometer while the one adjacent to the time scale gives the temperature record when controlled by the automatic attachment of the Callendar Recorder. It will be noted that in the latter record the mean temperature remained constant to one or two hundredths of a degree centigrade, each single division on the record sheet corresponding to 0.2 degree. At the same time the small range oscillation of about a tenth of a degree which must be practically entirely in the outer case, persisted throughout the twenty-four hours, the frequency depending upon the difference between spectrograph and dome temperatures. The long record to the left was made with a new mercury contact thermometer, while the shorter one was made after considerable use when the mercury surface was oxidized. The secondary oscillation, although reaching about the same amplitude with the old, is much smaller with the new contact thermometer, but the mean temperature swings through a range of about 0.2 degree with the new and 0.5 degree with the old thermometer.

The advantage is decidedly with the recorder regulator and is on the average probably more marked than shown, as the mercury contact thermometer was new and giving much better results than after even moderate use. There seems no reasonable doubt that the temperature around the prisms and lenses does not vary much more than the hundredth of a degree while the control is operating. The continuous record of the mean temperature of the spectrograph is a decided advantage enabling one to see at a glance if anything goes wrong with the heating circuit. It has the further advantage, in case any question arises in the future as to the accuracy of any spectrogram, of at once determining whether the trouble is due to temperature changes. The practice here is to turn on the heating current about three hours before observing begins and turn it off at the end. An examination of the record shows at once from the preceding run of temperature in the spectrograph, the most advantageous point at which to set the regulator, so that the prism temperatures are not changed more than necessary.

A two-way plug-board is installed on the telescope tube so that by simply plugging to either side, the recorder may be con-

nected with the Cassegrain spectrograph or with an ultra-violet spectrograph at the principal focus of the 72-inch mirror. This spectrograph, recently obtained, is also provided with a resistance thermometer and its temperature can be controlled by the same recorder which thus serves for either spectrograph. It should be stated, before proceeding to describe the dome and mirror recorder, that this method of temperature control of the spectrographs has proved very satisfactory and certainly eliminates temperature changes from the sources of systematic error in spectrograms.

As has been previously stated, and, as is shown to the left in Plate I, an additional recorder was obtained for making continuous records of dome and mirror temperatures. The temperature scale on this instrument is two-fifths that of the spectrograph recorder, about 8 mm to the degree centigrade, the scale extending over 25 degrees, the spectrograph recorder over 10 degrees, and each recorder being provided with an auxiliary plug board with steps of 5 degrees to enable the range of the scale to be brought into accord with seasonal temperature changes. Three single open wound platinum resistance thermometers are provided for use with the recorder. One of these is placed about two feet above the upper end of the polar axis, not far from the centre of the dome, and records the dome temperature. The other two are attached to the sector cover over the 72-inch mirror, and when this cover is closed are situated about two inches above the east and west sides of the mirror. As has been already described*, the sides and bottom of the closed section of the tube are covered with a generous thickness of cotton felt and the open upper end of this section can be covered, except during observing, by a pad of three thicknesses of heavy woollen blankets laid over light boards across the opening. Thus these two thermometers will record the temperature of the air immediately above the east and west sides of the mirror and consequently probably the approximate temperature of the glass. A two-way plug-board on the tube enables either one as desired to be connected to the recorder, while another two-way plug-board below the recorder, seen at the lower left in Plate 1, enables either the dome thermometer or one of the mirror thermometers to record their temperature as desired.

**Pub. Dom. A'p'l Obs'y*, Vol. I, No. 1; also this JOURNAL, XIV, p. 177, 1920.

The two records to the right of Plate II show the changes of temperature in the dome and on the west side of the mirror on two consecutive days, July 25 and 26. The drum of each recorder makes one revolution in 25 hours and is reset, and the sheet changed when necessary, every morning about nine o'clock. In order to show the change of temperature near the mirror and at the same time indicate the run of dome temperature, the recorder was left connected with the west mirror thermometer and only plugged over every hour or so to the dome thermometer for a sufficient time to register its temperature. This continued until observing began, when the recorder was attached to the dome thermometer, while after observing ceased it was again connected with the west side of the mirror. The record on July 25, where the blanket pad was in place, shows that dome and mirror were at about the same temperature, 16°.5 at 9 a.m. After this the dome rose rapidly to about 21° about 5 p.m., when it again fell and during observing reached about 10°. While the mirror remained covered, the rise of temperature near it was only about 0°.2 while the dome temperature increased nearly 5°. This shows very clearly the remarkable efficiency of the insulating covering and the very slow change in temperature in the metal and glass, about 13 tons altogether, enclosed within it. While the mirror was open to the night sky the temperature of it and its surroundings, as indicated by the mirror thermometer after observing ceased, fell about 2°.5. The upper blanket cover was not placed on the tube although the sector shutter was closed down. The record on July 26 shows that, even with the cover off, the temperature around the mirror only rose 0°.5, while the dome temperature increased 3°.5. These and similar records show conclusively that the insulation of the closed section of the tube is amply sufficient to prevent any appreciable change of temperature around the mirror and that this arrangement is not only much simpler but probably better than any artificial cooling or regulation. If it were possible to predict the working temperature of the following night, then some artificial means of maintaining the temperature around the mirror at that figure would be desirable. But as this is not generally possible, the procedure followed here of insulating mirror and metal surroundings at the temperature when observing stops, gives

probably better results on the whole than any other method, and this seems evident by the reduction of the difference between mirror and dome temperatures on the night of July 26 as compared with July 25. Certainly any aberration due to temperature changes is generally unnoticeable and less than the disturbance due to atmospheric tremor except for a rather persistent but slight astigmatism at the beginning of the night. This is undoubtedly due to a rather different rate of change of temperature at the east and west sides of the mirror. On the west side is the much larger mass of metal of the declination and polar axes, and consequently, as the recorder persistently shows, there is an average difference of temperature of the east and west mirror thermometers of about 0°.3, the west side, owing to the greater mass of metal, changing more slowly than the east. This difference produces a slight astigmatism, but as it can always be focussed parallel to the spectrograph slit it is no disadvantage, but possibly somewhat advantageous in spectroscopic work. Consequently, while it could probably be diminished or removed by further insulation of the polar and declination axes, this has not seemed worth while when the telescope is used practically exclusively for spectroscopic work where such astigmatism does no harm.

These records are hence very valuable adjuncts to the telescope and spectrograph. For the former they give continuous records of the temperature changes in dome and mirror, not only enabling full information about the behaviour of the optical surfaces under observing conditions to be obtained but also giving reliable information about the efficiency of the methods adopted for controlling the temperature of the mirror. For the spectrograph, in addition to obtaining accurate continuous records of the mean temperature of the instrument, the Callendar Recorder enables its temperature to be maintained much more nearly constant than is possible with the ordinarily used devices.

Dominion Astrophysical Observatory,
Victoria, B.C.

January, 1922.

ABSTRACTS OF PAPERS PRESENTED AT THE RECENT JOINT MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

OBSERVATION VERSUS EXPERIMENTATION

By Joel Stebbins

In this address it was pointed out that most of the work of securing facts in physical science consists in observation and experimentation. The question often comes to the individual investigator whether he shall continue a long series of routine measures, attempting to obtain the highest possible accuracy according to known and tested methods, or whether he shall stop and try to introduce improvements or to devise something entirely new. Astronomers are primarily observers while physicists for instance are primarily experimenters. The paper brought out the relative strength and weakness of the two classes of workers, but emphasized that neither observation nor experimentation is of the greatest value without proper theorization. As science becomes more and more complicated it is increasingly evident that many problems can be solved only by the joint efforts of several individuals working together. It is this sort of co-operation that is being fostered by the National Research Council.

(The paper in full appears in "Science" of January 13, 1922.)

POPULARIZING ASTRONOMY

By C. A. Chant

An outline was given of the work which has been carried on in Toronto for a considerable number of years, largely through the Royal Astronomical Society of Canada.

In 1868 the Toronto Astronomical Club was organized, and, under different names, sometimes with periods of suspended animation, it existed until 1890, when the Astronomical and Physi-

cal Society of Toronto was incorporated. Twelve years later it assumed the name of Royal Astronomical Society of Canada and extended its field of operations.

By means of single lectures, sometimes addressed by the most eminent astronomers, as well as by special courses of elementary lectures, a large number of people have been reached. Particular efforts are made to interest the teachers in the subject in the hope that they will pass on some inspiration to their pupils.

Attempts have been made each year to have open-air meetings but the facilities for these are meagre, and in recent years a project has been started to secure a first-class observatory for Toronto. This is intended to accommodate the University and the Society and also to serve in a special way the citizens. A fine site has been secured, maintenance has been promised, but funds for the building have not yet been secured.

Great assistance has also been rendered to such organizations as the Boy Scouts, Girl Guides and more especially to the newly developed "Tuxis" organization. By instructing the leaders of the boys and by addressing meetings of the boys themselves the work is spreading; but the great need is a good central observatory where practical observations can be made and from which the work can be directed.

MEASUREMENTS OF THE SUN'S DISTANCE FROM ITS SPECTRUM

By Ralph E. DeLury and John L. O'Connor

The measurement of the sun's distance from its spectrum was proposed at Ottawa some years ago, and already a creditable value has been obtained by this novel method. It is believed that the method will yield a value within one part in a thousand, which is about as close as the solar distance is known by other methods. This method depends on the fact that the earth moves about the sun in a non-circular orbit; during one half of the year it pulls away from the sun about three million miles, and draws in towards the sun the same distance during the other half of the year. It reaches a maximum velocity from the sun in March, and towards the sun in October, this greatest speed to or from the

sun being about three-tenths of a mile a second, or a difference between the March and October speeds of over six-tenths of a mile a second. This quantity can now be measured to one part in a thousand, and consequently the distance of the sun can be determined to this degree of accuracy by the method.

MEASURE OF LINEAR DIVISIONS

By R. J. McDiarmid

This paper dealt with some work carried on with the Ottawa Meridian circle, by five different observers, during the years 1912 to 1917. The first part dealt with circle microscope readings, particularly the estimation of tenths. The work of three observers covers a period of six years, while the other two, two years and one year respectively.

This investigation brought out the marked tendency of each observer to read some special tenth or tenths, and this persisted throughout the period. In the case of the first observer the tendency was to keep to the whole division, 18% of the total readings were zero, and 41% of total was made up of .0, .1 and .2. The second observer had a decided preference for .8. The point .0, .3 and .8 made up 40% of the total readings. The personality conditions were not so consistent as in the previous case. The third observer showed pronounced tendencies such as .6 as a maximum and .5 as minimum. The observations from year to year were not as consistent as in case of the two previous observers. The other observations examined did not reveal any pronounced tendencies except in one case where the zero was greatly favoured. It was interesting to note that for the five observers, there was an excess of even numbers. These percentages were 54%, 52%, 57%, 51%, and 56% in the order referred to above.

The second part of the paper dealt with the printing chronograph records. In this case there were six observers making readings of these records and it was the last figure in their record that was considered. Counts were made as in the previous investigation. For the three observers mentioned in the first part the results were as would be expected from probability, while the records of the three other observers, showed, that in case of one there was a

tendency to select odd numbers, 61% of the total, while the other two observers favoured the even numbers, nearly 70% in each case, to 30% odd. These conditions were very consistent. The results Albrecht published in the *Astronomical Journal* December 20, 1920, seem to be in many cases similar to those found among the Ottawa observers.

THE THERMOPILE PHOTOMETER OF THE OTTAWA OBSERVATORY

By R. M. Motherwell

This photometer is practically a replica of the instrument designed by Dr. H. T. Stetson, to whom the writer is much indebted for many details supplementing the published description.*[1] The thermopile[2] was designed by Dr. Coblentz of Washington. It is made of bismuth and silver couples, the wires being joined by beads of pure tin; and the receiving surfaces are quadrants of tin covered with a mixture of lampblack, platinum black and shellac. There are four couples, the quadrants being arranged so as to form a circular receiving surface and insulation being obtained by a coating of shellac. The thermopile is mounted in a hard rubber tube which is enclosed in a hard rubber box packed with absorbent cotton to prevent any sudden changes of temperature. A glass covering over the mouth of the tube protects the thermopile. A high sensitivity galvanometer is connected in series with the thermopile.

The source of light is a 20 c.p. gas-filled automobile lamp fed from a storage battery. The filament is small, thus giving an intense light from a small area. The light passes through a condenser of four inches aperture and about six inches focus, then through an opening in the stage of the instrument, through the projection lenses and down to the thermopile, the optical system being designed to give minimum absorption with maximum utilisation of the cone of light passing through the stage.

[1] *Astrophysical Journal*, 49, 253, 1916.

[2] *Bulletin of the Bureau of Standards*, 2, 168.

(*Continued in next issue*)

THE REFORM OF THE CALENDAR

By Carl Reinhardt

THE Vatican has announced that a conference of astronomers and others interested will take place in Rome next April under the presidency of Cardinal Mercier, with the object of reforming the calendar. The church appears to be mainly interested in bringing about a fixed Easter, but the desire is widespread, particularly among manufacturers and merchants of seasonal goods, that this festival should fall on, or at least nearly on, the same day every year.

This action of the Vatican also raises the hope among astronomers that the larger, often discussed question of a more complete revision of the calendar may be arranged at the same time, for it has been considered by many that the opposition to a fixed Easter by the church, now shown to be non-existent, might offer the most serious stumbling block to any reform.

The most desirable change which can be made with the least dislocation of our present calendar, and which is incorporated in most of the proposed methods of reform, would be to have the same day of the year always fall on the same day of the week. As there are 52 weeks plus one day in a year of 365 days, and plus two days in a leap year, by adding this extra day or days, and not considering or designating them a day of the week or month,—every day of the year will always fall on the same day of the week.

New Year's day, which is observed as a commercial holiday in nearly every part of the civilized world, seems to be by general consent the one best adapted to be made the non-week-day in every year. There is not the same agreement in the proposals, however, as to the position in the calendar which Leap Year Day,—the extra non-week-day in leap year, is to occupy. It seems extremely desirable that it should be the *last* day of the year. Only in this way can the proposed "Fixed Calendar" deserve the name. To place it following New Year's Day, or between the end of June and the first of July, as has been frequently suggested, would alter the position in the calendar of every day following it in that year, and one of the greatest advantages of a fixed calendar in astronomical and nautical calculations, banking and other reckonings, would be lost.

To have a second extra day during the holiday season at New Year's should be acceptable to all nationalities, while a holiday of no religious or commemorative significance in the middle of the year, would be both inconvenient in the commercial world, and interrupt a busy season in the industrial world. Placed in the holiday season as the last day of the year, and therefore next to the other non-week-day,—New Year's Day,— it will also make each half of a leap year the same length, 183 days. "Leap Year Day" should undoubtedly be the last day of the year, no matter what other reform is adopted.

Having disposed in the above way of the extra day or days in the year over the even 52 weeks, the same day of the year will in future always fall on the same day of the week, and it only remains to consider how best to subdivide these 364 days into months. Of the methods which have been proposed, three only are likely to receive consideration.

* * * * * *

The first which we will consider, because it necessitates but little change from out present calendar is that proposed by Prof. L. A. Grosclaude, of Geneva, Switzerland.

The year would have twelve months as at present, each quarter of 91 days divided into three months of 30, 30, and 31 days, and so his fixed calendar would be as follows:

GROSCLAUDE'S FIXED CALENDAR

January, April July and October							February, May, August and November							March, June, September and December						
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
	1	2	3	4	5	6				1	2	3	4						1	2
7	8	9	10	11	12	13	5	6	7	8	9	10	11	3	4	5	6	7	8	9
14	15	16	17	18	19	20	12	13	14	15	16	17	18	10	11	12	13	14	15	16
21	22	23	24	25	26	27	19	20	21	22	23	24	25	17	18	19	20	21	22	23
28	29	30					26	27	28	29	30			$\frac{24}{31}$	25	26	27	28	29	30

This calendar has received very general approval throughout Europe, particularly by Chambers of Commerce, since it achieves its main object, a perpetual calendar, with the least possible change from our present one, no date in the latter having its position from the beginning of the year altered by more than two days in the proposed one. Each month has 26 working days, and each quarter is the same length, making it possible to compare production costs of one period with another in any industry. Each quarter begins on a Monday and ends on a Sunday, a convenience in closing accounts. Its disadvantage lies in the fact that the months do not begin on the same day of the week throughout the year, and it would therefore still be necessary for all except those with a good memory to consult a calendar to learn the day of the week of any day of the month.

During the year 1912 a letter was put in circulation through the Swiss diplomatic service asking the opinion of scientific and commercial men upon this method of reform, and it will no doubt receive careful consideration at the coming conference called by the Vatican.

* * * * * *

The second method of reform to be considered here was discussed in the British Parliament in the year 1911, when Sir Henry Dalziel presented his "Fixed Calendar Bill."

In this also our present subdivision of the year into twelve months is retained, but it has the very desirable feature added of having the same day of every month as well as of the year always the same day of the week. This is accomplished by making all the months begin on Sunday and end on Saturday, and since it is impossible in a year of twelve months to avoid a difference in length of the months, it is as well to increase this difference to a full week.

Each quarter of the year is the same length, 91 days or 13 weeks, and is subdivided into two short months of 28 days or 4 weeks, and one long one, the third, having 35 days or 5 weeks. January, February, April, May, July, August, October and November, would thus have 28 days, and March, June, September and December, each 35 days.

"DALZIEL'S FIXED CALENDAR"

Four Week Months Jan., Feb., April, May, July, Aug., Oct., Nov.						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
Five Week Months March, June, Sept., Dec.						
29	30	31	32	33	34	35

All the desirable features of this calendar are attained with no serious alteration from our present style, and also with but little change in the date of any occurance or anniversary from that which it at present occupies. The average change for the year is only two days, and the greatest change which any date would undergo only amounts to four days.

It has the advantage to industries of making a comparison in production costs possible for each quarter year, simplifies a comparison of monthly costs over our present calendar, and greatly enhances the value of the week as a measure of time.

The advantage in computing bank interest, rents, etc., where the quarters are of the same length is obvious, and this advantage would be still further increased if the legal difficulties could be arranged so as to make the two non-week-days also non-interest or rent bearing days, so that 364 days could be known as a "Bankers' Year," when the quarter and the week would both be exact subdivisions of the year.

It has been suggested that the last week in the four long months be given a special name, such as Easter Week at the end of March, (Easter Sunday being the first day of April). Midsummer Week at the end of June, Michaelmas Week at the end of September or better still "Thanksgiving" or "Harvest Home Week" if this

festival were observed at this more seasonable date. Christmas Day will probably be celebrated one week before the New Year on Sunday, December 29th, Christmas Week being the last in the year. This plan, however, is one that could reasonably be left to each nationality to decide for itself, since it is not an essential part of the calendar.

The bill in which this calendar was presented to the British Parliament called for the insertion of the extra day in leap year between the last day of June and the first day of July. As already stated it would be much more convenient to the astronomer, navigator, banker and others to have Leap Year Day the last day of the year. With this single alteration, the proposal seems to be the most desirable of any plan yet proposed.

* * * * * *.

The third and last "Reformed Calendar" to be here considered is the "Thirteen Months Calendar" proposed by the French philosopher Auguste Comte nearly a century ago, and frequently discussed since by scientific societies and commercial bodies in various modified forms, but essentially the same in its main features. It has also been several times presented in the form of Bills to the British and other legislative assemblies of both Europe and America.

The adjustment necessary to make the year always begin on the same day is made similarly to the other two calendars, and the 364 remaining days are divided into 13 months of 28 days each, each month beginning either on Sunday or Monday.

The extra month is inserted either in the spring, midsummer or at the end of the year, and given different names by its special advocates, so that the fixed calendar for all months is as follows:

THIRTEEN MONTHS CALENDAR

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	31	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

This has the advantages of all months being equal in length, and the day of both the year and month always falling on the same day of the week, but these advantages are more than offset by the disadvantages of altering the dates of a considerable part of the year, and so causing serious dislocation in the commercial world, in ecclesiastical festivals, and in agricultural and commemorative anniversaries long established by precedent. The year is not conveniently divisible into halves and quarters, thus also seriously interfering with the current of many banking and commercial transactions in long and constant use.

* * * * * *

It has always been difficult to secure legislation for reforms of this character. Take for example the long fight which has been unsuccessfully waged to secure the adoption of the metric system in North America and Great Britain, or a decimal currency in the latter country. It is going to be doubly so to secure the simultaneous and identical legislation necessary in the present case.

In the final analysis it is the individual national parliaments, dominated largely by commercial interests, which will accept or reject whatever plan the coming conference in Rome adopts or recommends, and until public opinion has been educated to the point where the demand is unmistakable and insistent, and some degree of unanimity reached regarding the specific reform wanted, it will be impossible to secure from the politician the passage of such a law.

The goal of the astronomer is to obtain a fixed international calendar. Any of the three plans outlined above secures him this, and though a particular one of these may appear the most desirable, in reality it is not of vital importance to him which is chosen.

Quite a few scientific societies, as well as commercial and other bodies have unqualifiedly endorsed the 13 months calendar, often, it would appear, without a full knowledge of the other plans, and a bill is now before the House of Representatives of the United States in favour of it. On the other hand, European opinion appears to favour Grosclaude's proposal. Dalziel's method has many adherents in England, as securing the best features of the other two plans and offering an excellent compromise between the requirements of the banker and the manufacturer.

It is certain, therefore, that there will be disagreement at the conference as to which one is best. In view of this it would appear to be good policy for astronomers to exert all their influence mainly to secure a fixed calendar under any of the plans, and not to give unqualified support to any specific one, until the discussion between the many interests involved has demonstrated which will be the most acceptable to the largest majority.

Moveover, it is most desirable that everyone to be affected be given an opportunity to voice their needs in advance of the conference. Otherwise they will demand and secure such opportunity when legislation is sought from their national legislatures, and under a representative form of government, even a small minority is often able to effectively block desirable legislation.

If identical legislation is to be secured among all nations, discussion of the merits of different methods must not be left to the politician, but come to him in a specific form, unanimously endorsed by a body so authoritative, impartial, and international, that its judgment cannot be questioned. Such a body is the one soon to gather in Rome.

This body will meet lacking one essential. Its purpose will be to consider a question having such an intimate bearing as the reckoning of time on the future daily life of a large part of the inhabitants of the earth, yet only an infinitesimal minority of these have even heard of it. Representative as this meeting will be of both intellectual and powerful financial interests, they could better appreciate the requirements of this vast multitude, and be more likely to secure the aid of the forces able to command the required legislation, if a publicity compaign were immediately inaugurated through the press, presenting side by side, and inviting discussion on the different plans of making this much to be desired reform.

The action of the Vatican in convening the conference has once again made the question a live issue, and since astronomical almanacs take years in preparation, if success is to be achieved in time to inaugurate the change in 1927 or 1928—the most convenient years in which to make it—immediate and vigorous action should be instituted by everyone interested.

Cobalt, Ont., Canada.
December 29th, 1921.

MEETINGS OF THE SOCIETY

AT WINNIPEG

December 14, 1921.—The Society met in the University Arts Building, the President, Prof. N. R. Wilson in the chair.

This was the Annual Meeting and the reports of the secretary-treasurer as well as the list of officers appear on another page in this issue of the JOURNAL.

Messrs. Bastin and Allan, who had audited the accounts of the treasurer, were re-elected auditors for 1922. The reports of the auditors and of the secretary-treasurer were accepted.

The Council recommended that nominations for two members of the Council be restricted to members of the Society who have never before served in this capacity and that these nominations be left open by the Council. It was pointed out by the chair that nominations by the Council did not preclude other nominations for the same offices. The recommendation, on motion by Mr. Bastin, seconded by Prof. McLean, was adopted.

After the election of officers the President-elect, Mr. H. B. Allan, took the chair, and after a few remarks regarding the programme for the coming year, called on Prof. N. R. Wilson for the lecture of the evening, on "The Origin of the Earth".

The speaker showed lantern slides of star groups, and of various spiral nebulae, and explained how the composition of distant luminous bodies can be determined by the aid of the spectroscope, illustrating the effects obtained with the spectroscope, by means of coloured slides. He then outlined briefly the history of the Laplacian nebular hypothesis of the origin of heavenly bodies, stating that this idea is traceable through various races, to times before the Christian era. Some inadequacies of the nebular hypothesis were pointed out, and the speaker then explained the underlying principles of the recent planetesimal hypothesis. The enormous eruptions observed on the sun in present times, support the belief that a star, passing by chance near the sun and swinging around it, would tear loose eight separate masses, in pairs, coming off at each of four positions of the star for which the tidal and disruptive action is greatest. These are the positions at which the star would pass through the planes of two disruptive regions, located on either side of the sun's equator. This hypothesis furnishes the most satisfactory explanation of the origin of the earth and the seven other planets of the solar system.

After some discussion, and expressions of appreciation of Prof. Wilson's lecture, the meeting adjourned.

C. D. MILLER, *Secretary.*

AT TORONTO

January 24, 1922.—The Annual "At Home" of the Society was held in the Physics Building of the University at 8 p.m., the President-elect, Mr. W. E. W. Jackson, in the chair.

The Chairman after welcoming the large number of members and their friends, read the names of the newly-elected officers for the year 1922. He then called upon the retiring President, Mr. J. R. Collins, to address the meeting.

Mr. Collins first summarized the activities of the Society during the past year, in which a substantial increase in membership had been obtained. He referred briefly to the project for securing an observatory for Toronto, and expressed the hope that the building would soon be erected.

The subject of his address was "Modern Theories of the Universe", in which, after mentioning the early Greek conceptions of Pythagoras, Anaximander and Eudoxus, he discussed at some length the shape and size of the Milky Way, and many of the problems connected with it. The modern views of Shapley and Curtis were explained and illustrated by a number of slides.

After the address the members spent an interesting hour examining the exhibits illustrative of the work of the Meteorological Service, which consisted of seismographs and seismograms, a magnetometer, pilot balloon equipment, meteorographs and their records, anemometers, etc. Each part of the display was explained by a member of the staff of the Meteorological Office.

Light refreshments concluded a pleasant evening. The meeting adjourned at 10.45.

February 7, 1922.—The Society met at 8.15 p.m. in the Physics Building of the University, the President, Mr. W. E. W. Jackson, in the chair.

The following were elected members of the Society: Rev. E. F. Maunsell, B.A., Christ Church Rectory, Nanticoke, Ont.; Angus P. Stevens, Durham, Quebec; Carl Reinhardt, B.Sc., O.L.S., Cobalt, Ont.; N. H. Ramer, 175 Jackson St. W., Hamilton, Ont.; W. E. Mann, 18 St. Albans St., Toronto, Ont.; E. E. Wright, 388 Quebec Ave., Toronto, Ont.; W. H. Campbell, 170 Howland Ave., Toronto, Ont.; Charles A. Crook, 47 Ruskin Road, Toronto, Ont.; A. Hamilton, 14 Langley St., Toronto, Ont.

Dr. C. A Chant reported upon the recent appearance of Mercury. Although the planet was at its greatest elongation on January 29th, it was first seen on January 21st, and was observed upon succeeding evenings, with two exceptions, until the 31st, when the weather precluded further observations. The 4-inch equatorial telescope was mounted upon the roof of the Physics Building and placed at the disposal of the students and anyone interested. A notice appeared in the *Globe* on Saturday 28th, with the result that about 50 people turned out that evening. As many as 150 were on hand Monday evening, and many remained long after the planet had set to view the crescent moon through the telescope. The keen interest displayed by the public is surely indicative of the need for a municipal observatory.

Mr. A. F. Miller described the interesting sun pillar of January 11th. It appeared as a bright column of light, 15 degrees high and about a half a degree

wide, vertically over the setting sun. Its colour changed with the sky, being first yellowish, then orange and finally reddish. About 5.10 E.S.T., or some 10 minutes after sunset it gradually faded away. Mr. A. F. Hunter also spoke of this phenomenon, stating that the colour was due to refraction. Dr. C. A. Chant, explained Humphreys' view that the pillar was caused by reflection from a layer of ice crystals high in the air; the case being of sunlight similar to the reflection of moonlight from the surface of water, the only difference being that the sun pillar has the colour of the sky.

Mr. Miller reported two interesting notes. The Director of the Meudon Observatory, France, stated in a report on the work accomplished during the year 1921, that M. Perraut had verified Einstein's prediction of the shifting of the solar spectrum towards the red. M. Perraut used a peculiar type of spectrometer, which has not yet been fully described in the publications of the Observatory. M. G. Hainey of the Paris Observatory has been experimenting with marked success upon the subject of photographing the stars of the 2.5 magnitude in daylight, using plates sensitive to red light and a screen to cut off the blue light of the sky.

The President then called upon Mr. Wm. Park, to show to the Society some of his motion pictures on astronomy and geography. Mr. Park stated that a number of years ago he was impressed with the need of motion pictures to adequately teach the subject of geography in Public and High Schools. His first films were made in New York and although the difficulties which had to be overcome were tremendous, the films were so successful that he planned to produce a series of thirty subjects. Twenty-two of these have been completed and are in circulation in the cities of New York, Detroit, Annapolis and Toronto.

Mr. Park then showed the following films:.

1. "Worlds in the Making", illustrating the nebular theory of the formation of the solar system.
2. "The Mystery of Space", showing the motions of the planets and satellites of the solar system.
3. "The Earth and the Moon", showing the relative sizes of each, diurnal and orbital motions, phases and eclipses.
4. "The Kingdom of the Storm", illustrating the meteorological side of modern geography, the origin and movements of storms.
5. "South America", a film to teach the physical characteristics of the continent, its shape, size, mountains and rivers, especially the great Amazon.
6. "The Romance of the Nile", showing the cause of the yearly inundation of the Nile and its economical effects.

The pictures were most interesting and instructive and should prove effective in the teaching of these subjects.

After appreciative remarks by some of the members, the meeting was adjourned.

J. A. Pearce, *Recorder.*

NOTES FROM THE METEOROLOGICAL SERVICE

Temperature and Precipitation, January, 1922

The temperature was below the average in British Columbia, varying from three to seven degrees. In the Western Provinces it was above from one to five degrees. In Ontario and Quebec it did not vary much from the average, some districts being slightly below while others were slightly above. In the Maritime Provinces it was from one to two degrees below.

The precipitation was below the average over the Dominion except in a few localities where there was a slight excess. In parts of Southern Ontario and the Maritime Provinces the deficiency was very marked, being between two and three inches. The chief positive departures reported were Barkerville, British Columbia .90 of an inch, and Sydney, Cape Breton .60 of an inch.

Magnetic Disturbances, December, 1921.

During the month of December there were no very pronounced disturbances in the Magnetic Forces recorded at Agincourt. A moderate disturbance was however recorded commencing during the night of the 27th and lasting until the 29th which was most pronounced in Declination. Several rather large departures from normal occurred which during the 28th carried the needle easterly and on the 29th reversed the direction and moved westerly; the movements however were very sluggish.

At Meanook marked disturbances were recorded on the 13th and again on the 28th and 29th. In both cases the movements were rapid and of considerable amplitude.

The aurora was seldom seen during the first three weeks of December, but observers from the Pacific to the Atlantic reported it almost every night from the 23rd to the 29th.

During the first week of the month no sunspots were visible. A large group was central on the 15th and smaller groups on the 21st and 29th.

W. E. W. J.

SEISMOLOGICAL NOTES FOR DECEMBER 1921 AND JANUARY 1922

December.—Victoria recorded six disturbances during the month, and Toronto, three. The most important occurred on the 18th, the epicentre being 5,000 km. distant from Toronto. The P waves of this earthquake as recorded at Toronto were minute and poorly defined, whilst the S and SR waves were large and came in very abruptly. P, 15h 37m 48s; S. 15h 44m 30s; SR, 15h 47m 30s G.M.T. Amplitude 2.5 mm. Victoria shows a trace amplitude of 1.5 mm.

January.—Marked seismological activity has been noticed during January both in the number of earthquakes recorded and the intensity of the disturbances. Victoria recorded 14 quakes and Toronto 11. The amplitudes were all larger than usual, and a number of them appear to have originated off the California coast.

The most important of the series occurred on the 9th, 17th, and 31st. The quake on the 9th was well recorded at Toronto. Preliminary waves came in at 5h 16m 24s G.M.T., and the distance to the epicentre was 3,330 km.

The seismograms of the 17th present some abnormal features, notably the very sudden oscillation of the Toronto boom about the time of the arrival of the S waves. The initial waves at Victoria which were registered at 4h 00m 39s may not be the true P waves. The oscillations on the Victoria seismogram were also very sharp.

The quake of the 31st was quite large and was recorded at many stations. The first wave of the earthquake was recorded at Toronto at 13h 24m 30s, and the maximum at 13h 40m, the amplitude being about 16 mm. The distance to the epicentre was 3910 km. from Toronto, the approximate position being off the coast of California not far from San Francisco.

J. Y.

TEMPERATURES FOR MONTH OF JANUARY 1922.

STATIONS	JANUARY Highest	Lowest
Yukon		
Dawson	26	—48
British Columbia		
Atlin	36	—10
Agassiz	45	11
Barkerville	38	—18
Kamloops	49	—12
New Westminster	46	18
Prince Rupert	55	15
Vancouver	45	15
Victoria	47	21
West Provinces		
Battleford	43	—43
Calgary	52	—24
Edmonton	47	—50
Medicine Hat	45	—24
Minnedosa	30	—40
Moosejaw	42	—39
Oakbank	33	—35
Portage la Prairie	..	..
Prince Albert	42	—40
Qu'Appelle	39	—40
Regina	..	..
Saskatoon	..	..
Souris	..	..
Swift Current	40	—30
Winnipeg	35	—38
Ontario		
Agincourt	42	— 5
Oak Ridges	42	— 8
Bancroft	38	—40
Barrie	40	—11
Beatrice	39	—28
Bloomfield	41	—12
Brantford	..	..
Chapleau	..	..
Chatham	52	0
Clinton	44	— 9
Collingwood	35	— 8
Cottam	..	..
Georgetown	38	— 9
Goderich	47	— 4
Grimsby	45	0
Guelph	44	— 6

STATIONS	JANUARY Highest	Lowest
Ontario—cont.		
Haliburton	36	—35
Huntsville	45	—33
Kenora	30	—39
Kinmount	39	—32
Kingston	42	—11
Kitchener	38	— 4
London	46	— 2
Lucknow	44	—11
North Gower	40	—20
Oshawa	..	..
Ottawa	40	—19
Paris	46	— 3
Parry Sound	34	—24
Peterborough	42	—21
Port Arthur	32	—27
Port Dover	45	0
Port Stanley	48	0
Queensborough	40	—30
Ronville	40	—37
Southampton	37	— 7
Stonecliffe	..	..
Stoney Creek	47	1
Toronto	46	— 1
Uxbridge	42	—13
Wallaceburg	27	— 6
Welland	50	— 2
White River	35	—47
Quebec		
Brome	41	—30
Father Point	32	—18
Montreal	39	—12
Quebec	36	—19
Sherbrooke	41	—21
Maritime Provinces		
Charlottetown	40	—12
Chatham	38	—22
Fredericton	37	—27
Halifax	40	—12
Moncton	44	—20
St. John	54	—12
Sussex	45	—20
Sydney	46	—12
Yarmouth	42	2

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

WHO CAN UNDERSTAND EINSTEIN'S THEORY OF RELATIVITY?

A story was widely circulated a short time ago which stated that Einstein when returning to the printer the proof of one of his papers on relativity remarked that he doubted if there were a dozen men living who could follow his line of reasoning. Almost every writer or speaker on the theory has disclaimed any suggestion that he himself was one of the gifted few,— and yet every one talks about relativity, whether he understands it or not. But now comes Einstein himself and says the story was a pure fabrication.

Recently there was published a pamphlet by George Henry Lepper, of Pittsburg, entitled "The Generalized Theory of Gravitation versus The General Theory of Relativity". Mr. Lepper is also the author of a large work, "From Nebula to Man". These works deal with profound and difficult problems and the present writer does not think himself capable of passing an opinion on them. Mr. Lepper, however, attacks the theory put forth by Einstein and wrote a letter of protest to him. He received a letter in reply which is printed as an appendix to the pamphlet. In the first paragraph Einstein says: "I never asserted that only a few persons are capable of understanding the general theory of relativity. This is a pure invention and never emanated from me. Every earnest student of theoretical physics is in a position to comprehend it". Another good story exploded! And the joke in it is that it could have been *stated with perfect accuracy*.

TWO BRIGHT FIREBALLS

(Letter to the Editor)

The interesting accounts of two fireballs in the *Journal of the R.A.S. Canada* for January, page 35, would have been more valuable had they contained more exact information as to the flights

of the objects in the heavens. Unless the positions are given in detail it is impossible to find the particular showers or radiants from which such bodies are derived. With regard to the fireballs reported in your columns as appearing on November 19th and 20th last, they occured at a significant date, for the end of the third week in November forms a special period for meteors from Biela's Comet, and from a rich shower of brilliant Taurids often seen in past years. Observers in reporting observations of conspicuous meteors would greatly enhance the value of their data if they gave the positions of the beginning and ending of the flights, as accurately as possible.

The R.A. and Declinations should be given, or the paths might be correctly assigned with reference to the naked eye stars lying near them.

The duration of flight is also an important element which should be estimated as correctly as posible.

Particulars such as these will always be valuable, and form a reliable basis on which investigations of the height, velocity, and radiant points may be determined.

W. F. Denning.

Bristol, Eng., Feb. 7th, 1922.

COOKING BY THE SUN'S HEAT

In the Report of the Astrophysical Observatory of the Smithsonian Institution for the year ending June 30th, 1921, the Director, Dr. C. G. Abbot gives an interesting review of the work of himself and his associates. Dr. Abbot's great objective for many years has been the determination of the so-called solar constant of radiation, but the by-products have been numerous and important. At first the measurements were made chiefly at Washington; then a station was established on Mount Wilson; later, one was secured in a cloudless desert in Chile; and now one has been erected on Mount Harqua Hala, in Arizona, a site 15 miles from the railway and 5 miles from a wagon road. It is hoped to continue observations in Arizona and Chile for several years in order to compare results and thus settle the variation of the sun's radiation.

Perhaps the portion of the report most interesting to the general reader relates to Dr. Abbot's invention of a reasonably efficient solar cooker. Instruments for utilizing the heat from the sun and power from the tides have been long desired and many attempts have been made to produce them, usually with not very satisfactory results. However, Dr. Abbot says his instrument is a practical success. It consists of a mirror of parabolic shape about 10 feet long, and 7 feet aperture, which brings the sun's rays to a focus on a tube filled with oil which circulates by convection to and from a reservoir of oil. In the rear of the reservoir two ovens are inserted. Food is prepared in the kitchen and is baked, boiled or stewed in these ovens. The apparatus proved to be especially satisfactory for the canning of fruit.

The fourth volume of the *Annals* of the Observatory is almost ready for publication.

OUR NEW CENTRE

We are very glad to announce the formation of a new Centre of our Society, with headquarters in London, Ontario. A few days ago the General Secretary received a letter from Prof. H. R. Kingston, asking that the Council sanction the organization of a Centre. Prof. Kingston, who was formerly with the University of Manitoba, and for several years an officer of the Winnipeg Centre, has recently been appointed on the staff of the Western University, and soon after taking up his new duties he gave some popular lectures on astronomy which aroused great interest and enthusiasm. On February 10th, a meeting was held at which a Constitution was formulated and officers appointed. Thirty charter members have been secured. A full account of the new Centre will appear in the April JOURNAL.

C. A. C.

The Royal Astronomical Society of Canada

OFFICERS FOR 1922 (Revised to March 1st, 1922).

Honorary President—Hon. R. H. Grant, Minister of Education for Ontario.

President—W. E. W. Jackson, M.A. *First Vice-President*—Wm. Bruce, J.P.

Second Vice-President—R. M. Stewart, M.A.

General Secretary—A. F. Hunter, M.A. *General Treasurer*—H. W. Barker.

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